SEEING your account of the aurora of February 4 in NATURE of the 22nd, reminds me that on the evening of the 4th I was riding from Cambridge to Coldwell, in Ohio, and between six and seven o'clock saw a most brilliant display of auroral light in the southern quarter of the sky. Brilliant streamers shot up past the zenith, while the whole southern portion of the sky was brightly illuminated with a corruscating rose-coloured light.

Marietta, Ohio., March 15 A. J. WARNER

Morse on Terebratulina

I HAVE just read the very kind notice of my paper* in the pages of your journal from the pen of Mr. E. R. Lankester. I hasten, however, to remove one impression conveyed in the following sentence, respecting the opinions I hold as to the Annelidan affinities of the Brachiopods:—

"We are not sure whether Mr. Morse adheres to this startling proposition."

I trust the long delay in publishing the results of my studies on this interesting class will lead no one to suppose that I have yet seen reason to modify the position I took two years ago regarding their position in the animal kingdom. On the contrary, continued investigation has brought out many new points of interest, and now I hope, ere my paper is published, to present the embryology of some one of them.

I had studied our native Terebratulina, its structure, as well as its early stages, and through the kindness of Prof. Verrill, had studied *Discina lævis* (upon which I hope soon to publish).

Mr. Lankester, as the author of many valuable memoirs requiring much skill and patient labour, will fully appreciate the time and care necessary in work of this kind.

As to my being unduly impressed at the sight of living Lingulæ, I may say, in justice to myself, and my friends will testify to it, my opinions were fully formed before I ever saw Lingula at all. With the caution that is requisite for every one, if he does not wish to supplement his paper with a correction of errors, a way of doing things altogether too frequent in this country, I deemed it important to study living Lingula before publishing. It was impossible for me to go half-way round the world for it. And as three specimens of another species have been found on the coast of North Carolina, I determined to go there. A trip of nearly a thousand miles brought me to its waste of drifting sands.

Thoroughly convinced as to the correctness of my views, and these views of sufficient strength to convince my co-labourers, Mr. Lankester will understand my enthusiasm when, after a week's fruitless search under a blazing sun, and an almost hopeless task, I found Lingula, not as we have always supposed attached by its peduncle, but living in the sand, precisely like many tubicolous worms, building a true sand tube, and when liberated from it crawling and burrowing by means of its setæ, and with all these welcome characters it should greet me with red blood. Not that I lay great stress on any one of these characters, but having made my deductions from the most common form, Terebratulina, one can readily understand the bearing of such unexpected characters in this little Lingula.

Mr. Lankester will admit that the Vermian lumber-room has some orderly compartments; into one of those I place the Brachiopods far away from all Molluscan odours.

The distinguished naturalist, Prof. Steenstrup, informs me that he has long taught his classes at the University of Copenhagen that the Brachiopods were true Annelids, and that my views are thoroughly endorsed by him. To him, therefore, and not to me as had been supposed, belongs the priority of this discovery.

I only ask a little patience till my complete paper is published on the Brachiopods as a division of Annelida, in which I shall give appropriate figures, and my reasons in full for the position I have taken. EDWARD S. MORSE

Salem, Mass., U.S.A., March 14

On the Colour of a Hydrogen Flame

WHEN hydrogen and oxygen are burned together, it is well known that the flame produced is almost non-luminous; it always, however, exhibits an unmistakeably blue tinge.

The small illuminative power is generally referred to the "absence of solid particles." This view, it appears to me, draws a too rigid line of demarcation between the atoms of carbon in an ordinary gas-coal flame and the atoms of hydrogen in that of the oxyhydrogen. The cause of the phenomenon does not depend so much on the *solidity* as it does on the time of oscillation of the particles which constitute the flame. Water particles in all their states of aggregation preserve the same time of oscillation—extra red; hence a hydrogen flame should be perfectly invisible whatever may be the "solidity" or density of its particles.

But the flame is not invisible, and, what is still more remarkable, the colour which it does exhibit is found to belong to the most refrangible end of the spectrum. To explain this strange phenomenon, it appears to me that it is necessary to invoke a state in the ether particles similar to that which Helmholtz has shown to exist in air; and which is this:—A tuning-fork "vigorously struck against a pad emits the *octave* of its fundamental note." Now, the first overtone of a tuning fork is produced by vibrations about $6\frac{1}{4}$ times as rapid as the fundamental; the octave, therefore, is not an overtone of the fork—it is produced solely in consequence of the fact that the initial disturbance is great in proportion to the distance of the air particles from one another, secondary waves being produced whose periods are twice as rapid as those of the fundamental.

The amplitude of the particles in a hydrogen flame is known to be very great, and hence it seems probable that an effect may result from the disturbance thus created in the ether, analogous to that in the case of air, *i.e.*, associated with the fundamental vibrations of the hydrogen flame we have their *octave*, which would obviously be within the visual range, and correspond very closely, if not *exactly*, with the colour actually observed.

Should this surmise prove correct we have plainly an easy means by which we can determine the wave-length of those extra-red rays which are absorbed by water.

A. G. MEEZE

Hartley Institution, Southampton, March 26

P.S.—May not the great *actinic* power of the electric light be due in a great measure to the secondary waves produced by the magnitude of the disturbing force?

VESTIGES OF THE GLACIAL PERIOD IN NORTH-EASTERN ANATOLIA

ATTENTION was drawn to this subject in a lecture given on March 25 at the Royal Geographical Society by the Eastern traveller Mr. W. Gifford Palgrave, at present British Consul for the northern coast of Asia Minor. The facts which he mentioned had been principally observed by him during a tour on duty to the interior about two years ago; and the line of route lay from the town of Trebizond on the sea coast to that of Erzinghian on the Upper Euphrates.

The phenomena themselves were divided into two classes: the one referable to the highlands which he had then traversed, the other to their marginal region.

These highlands are situated on or near the 40th parallel of latitude, and extend between the 37th and 44th of longitude, east and west; their average breadth being about fifty miles, and their elevation varying from 3,000 to 9,000 feet above the sea. They constitute the great watershed of Eastern Anatolia; the rivers to the south of them flowing into the Persian Gulf, and those to the north into the Black Sea. To the west is the basin of the Halys, to the east that of the Caspian.

The road leading across this plateau towards Erzinghian, mounts up to it by a defile named "Ketcheh-Dereh," or "Goats' Valley." Here, at a height of about 5,400 feet above the sea, Mr. Palgrave came on the lower extremity of a large moraine, piled up to a height of more than twenty feet, and broad in proportion. Following it for a distance of nearly half a mile, he found that when it had reached between 400 and 500 feet higher up the slope, it forked into two lesser branches, continued each a good way further into the rising undulations of the table-land.

The plateau itself bore every mark of having lain under a thick ice-coating; its eminences and irregularities all bearing the "moutonnée" character impressed by glacial action; while it was also frequently strewn with detached

* "Early Stages of Terebratulina."

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boulders and pieces of rock, scratched and scored with the unmistakeable lines that glaciers alone produce. These phenomena he observed to be repeated, or rather continued, throughout the highland, which he crossed three times at intervals, including above 100 miles of its length.

About the midmost of the plateau stands a solitary, dome-like eminence, nearly 8,000 feet above the sea level, and rounded off in every direction. On the west side of this mountain, now known as "Yelish Dagh," near its base, Mr. Palgrave found a second moraine, consisting of a single stone bank five or six hundred yards in length, stretching down to a valley below: its higher extremity was at about 6,500 ft. And lastly, at the great cleft about fifty miles distant, called the Cherdakh Pass, and leading downwards from the plateau into the Euphrates valley, he observed a third moraine, larger than either of the two former, and extending over a slope of fully 2,000 ft., its base being only about 4,500 ft. above the sea.

From these and similar indications, Mr. Palgrave conjectured that during the glacial period an ice-cap of fifty miles in average breadth, and many hundred in length, must have covered this table-land from a height of 6,000 ft.. or rather less, upwards; while some of the more advanced glaciers may have reached to a far lower level, seemingly 4,000 ft.

Such were the most remarkable surface-phenomena of the plateau itself. But on its margin, whether north or south, and connected with it, were other indications of an analogous character. These consisted in the traces afforded by broad and deep ravines and neighbouring river beds, much too wide for the streams that flow through them; all affording evidence of a past epoch when the water supply was on a far more copious scale than it is now. Thus the valley of the Euphrates itself, which takes its rise in this very plateau, is, in its evenly-scooped extent of three and even four miles across, out of all proportion with the comparatively little and feeble stream that now meanders along it; and the same must be said of most of the aqueous modifications imprinted in the lower mountain ranges, and in the plains at their feet.

But of all the phenomena of this kind none is more remarkable than that inspected by Mr. Palgrave near the sea-end of the great valley by which the river, once Pyxartes, now "Deyermend-Dereh," or "Mill Stream" enters the Euxine, close by Trebizond. This river, whose waters are derived from the central table land, is now so shallow as to be readily fordable at almost every season of the year, and brings down with it just enough pebble and soil to form a little bar at its mouth. Half a mile, however, from the present beach the river valley, here about a third of a mile in width, is in its greater part crossed by a huge bar of rolled stones, at least forty feet in eight, and eighty or a hundred yards in thickness at its base, evidently formed here by the joint action of river and sea. The stones, many of which are of great size, belong to Jurassic or Plutonic formations, such as compose the plateau inland, whereas the coast-rock is entirely volcanic. But the flood of water requisite to bring them from such a distance is now wholly wanting. Nor can its diminution be ascribed to the extirpation of forest wood, for the mountain chain is still as densely clothed with trees as it could ever have been in remote times; nor yet to an alteration in the course and dip of the valleys that unite to send their supplies hither, for there is no trace of any great geological change hereabouts within the epoch to which the bar itself is referable. One only cause there could have been capable of furnishing so impetuous a stream, namely, the periodical melting of great masses of ice and snow on the mountains behind, now unusually bare of snow from June till November, and absolutely denuded of anything approaching to a glacier. When these icy reservoirs ceased the abundance of the river ceased also, leaving the bar alone as a monument of its former strength. T. P.

THE INHABITANTS OF THE MAMMOTH CAVE OF KENTUCKY

CRUSTACEANS AND INSECTS

THE following account of the inhabitants of the Mammoth Cave of Kentucky is abridged from the *American Naturalist*. To the courtesy of the editors of that journal we are further indebted for the accompanying illustrations:—

After the adjournment of the meeting of the American Association for the Advancement of Science, held at Indianapolis in August last, a large number of the members availed themselves of the generous invitation of the Louisville and Nashville Railroad Company, to visit this world-renowned cave, and examine its peculiar formation and singular fauna.

The cave is in a hill of the subcarboniferous limestone formation in Edmondson County, a little to the west and south of the centre of Kentucky. Green river, which rises to the eastward in about the centre of the State, flows westward, passing in close proximity to the cave, and receiving its waters, thence flows north-westerly to the Ohio. The limestone formation in which the cave exists is a most interesting and important geological formation, corresponding to the mountain limestone of the European geologists, and of considerable geological importance in the determination of the western coalfields.

We quote the following account of this formation from Major S. S. Lyon's report in the fourth volume of the "Kentucky Geological Survey," pp. 509, 510:—

"The sinks and basins at the head of Sinking Creek exhibit in a striking manner the eroding effects of rains and frost—some of the sinks, which are from 40 ft. to 190 ft. deep, covering an area of from 5 to 2,000 acres. The rim of sandstone surrounding these depressions is, generally, nearly level; the out-cropping rocks within are also nearly horizontal. Near the centre there is an opening of from 3 ft. to 15 ft. in diameter; into this opening the water which has fallen within the margin of the basin has been drained since the day when the rocks exposed within were raised above the drainage of the country, and thus, by the slow process of washing and weathering, the rocks which once filled these cavities have been worn and carried down into the subterranean drainage of the country. All this has evidently come to pass in the most quiet and regular manner. The size of the central opening is too small to admit extraordinary floods; nor is it possible, with the level margin around, to suppose that these cavities were worn by eddies in a current that swept the whole cavernous member of the subcarboniferous limestone of western Kentucky; but the opinion is probable that the upheaving force which raised these beds to their present level at the same time ruptured and cracked the beds in certain lines: that afterwards the rains were swallowed into openings on these fractures, producing, by denudation, the basins of the sinkhole country, and further enlarging the original fractures by flowing through them, and thus forming a vast system of caverns, which surrounds the western coalfield. The Mammoth Cave is at present the best known, and therefore the most remarkable."

So much has been written on the cave and its wonders, that to give a description of its interior would be superfluous in this connection, even could we do so without unintentionally giving too exaggerated statements, which seems to be the natural result of a day underground, at least so far as this cave is concerned, for, after reading any account of the cave, one is disappointed at finding the reality so unlike the picture.

We are indebted to Prof. Alexander Winchell, of the University of Michigan, for the following abstract of his views concerning the formation of the cave:—

"The country of the Mammoth Cave was probably dry land at the close of the coal period, and has remained

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